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The Challenges of Designing and Successfully Delivering a new Masters Level Unit in Infrastructure Asset Management

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Abstract

Between 2013 and 2015 I scoped, designed and delivered a new Masters Level (L7) Unit in Infrastructure Asset Management as an option for the Department of Civil Engineering. Asset Management is a relatively new profession with many career opportunities for graduates. Here I use the Gibbs framework to reflect on and evaluate the overall approach to design, student recruitment, delivery and feedback from the first three years of running the Unit. I also critique the use of co-creation with students in Unit design working with four final year students, the impact of Technology Enhanced Learning, and the Unit's linkage to the professional competencies required by the Institute of Asset Management. I conclude the case study with a summary of 'what will I do differently next time' in line with Gibbs' model.

1 Introduction

In this case study I reflect on the design challenges, learning opportunities and teaching skills I needed to develop in order to create and successfully deliver a new Masters Level (L7) Unit in Infrastructure Asset Management. The Unit's outline was based on my discussions about future career opportunities in utilities with the third-year cohort in my first year of teaching at Bristol in 2013/14. In subsequent consultation with my department's senior management, the Unit's broad outline was agreed with the then Head of Department and Civil Engineering's Programme Director.

1.1 Design and Student Mix

In 2013, the Department agreed that the Asset Management Unit (AM4) would be a valuable addition to the Civil Engineering programme for final year students, starting in the second teaching block of the 2014/15 academic year. Hence, I led its initial concept in late 2013, created its outline in early 2014, and led its first delivery in Teaching Block 2 2015. In Figure 1 I have summarised the Unit's development and delivery timeline.

About half of the final year Civil Engineering and some Engineering Design students have chosen this elective in its first three years (typically 35 to 45 students). They are a diverse mix of UK, EU, Erasmus and non-EU international students, demonstrating the range of interest and increasing international importance of Infrastructure Asset Management. I also co-created the Unit to cater for international requirements and as a 'feeder' for related post-graduate qualifications, such as those offered by the Institute of Asset Management, where I am the Chief Examiner. This 'feeder' approach also relates to my professional knowledge and research about future employability and practical skills needed in Asset Management.

1.2 My Initial delivery and Reflection

I have now delivered the AM4 Unit three times with updates and changes based on a mix of student evaluation obtained through formal Unit reviews/feedback, discussion with colleagues at Bristol, and industry feedback. Therefore, my approach to this case study is to reflect on and critique the overall design, my delivery challenges and recommended improvements using the Gibbs Reflective Cycle model¹. In line with Gibbs' Cycle, the

¹ Gibbs, G. (1998). Learning by Doing: A Guide to Teaching and Learning. London: Further Educational Unit

lessons I learned from the first two delivery cycles in 2015 and 2016 were used to plan changes and updates in the second and third cycles in 2016 and 2017 respectively.

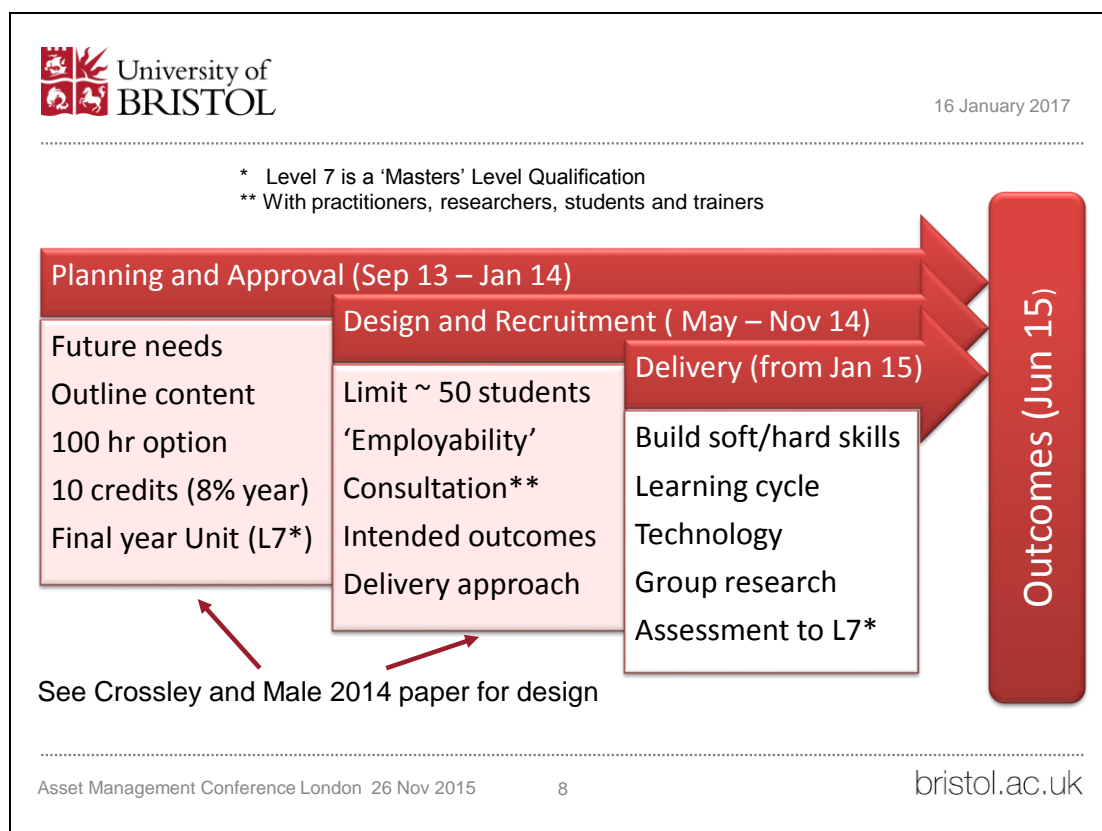


Figure 1. The Timeline from Concept to Delivery of Asset Management 4

This reflective approach to planning improvement aligns with the concepts of Cowan and Harding² who stated that that “*evaluation, in the context of curriculum development, is a formative review which pinpoints scope and suggestions for improvement in the next iteration of the systematic process.*” Therefore, the Unit review and student evaluation is important to embedding both good practices and learning from my delivery experience.

At the outset, I felt relatively pressured to meet the tight timescales to contextualise, design and gain approval for a brand-new Unit. This was because I was new to the process of Unit design and compliance at Bristol. Based on my three years of subsequent delivery experience, the case study highlights some of the key lessons I have learned for Unit design within the modern student learning environment with the adoption of both co-creation and Technology Enhanced Learning. Suffice it to say, I am still improving delivery, incorporating pedagogical research and relevant good academic practices into the Unit. As the saying goes, “*good, better, best – never let it rest. 'Til your good is better and your better is best.*”³ Hence, I have been repeating the Gibbs' Cycle as follows: Design - Assess Delivery – Reflect on Possible Improvements – Modify aspects of design (based on student feedback and cohort results) – Assess Latest Delivery. Then repeat the cycle.

² Cowan J. and Harding A G, (1986) A Logical Model for Curriculum Development, British Journal of Education Technology 17.2 pp 103-109

³ Attributed to St Jerome who lived from 347 to 420 AD

2 Asset Management Unit Design

Based on my positive external experiences working with Clients and decision makers to define their projects' scope, expected outcomes and critical success factors, I felt that some form of Unit co-creation could work. However, in 2013 there was limited experience within the School and Department about Unit co-creation. In 2012 there had been some international research into the subject of co-creation in the European Higher Education Area by Diaz-Mendez and Gommesson⁴. They recommended "*a shift of perspective from a value delivery approach – doing something 'to' students – to a co-creation approach – doing something 'with' students,*" albeit with caveats on the correlation of 'students as customers'.

The co-creation concept made sense to me, from my professional services standpoint, and so I worked with my students to co-create the Unit to align with (and feed into) many of the requirements of the Professional Certificate and Diploma of the Institute of Asset Management (IAM). Given my expertise in Asset Management, and knowledge about professional accreditation as a member of the IAM's Exams Committee (see Annex A), our alignment was designed to maximise the Unit's credibility to students and their future employers, as well as demonstrating sound professional practice. Such alignment agrees with a second Cowan and Harding assertion that "*the decisions on what should be taught, to whom, by whom and with what emphasis, are influenced by factors which come mainly from outside the process of curriculum development, from the society of which teachers are a part and to which teachers are answerable.*"

To publicly promote this linkage, the Unit's design and delivery have been written up as papers for the International Asset Management Conferences in 2014 (dealing with Unit design) and 2015 (dealing with Unit delivery) by myself and Steven Male^{5 6}. With the University of Bristol's funding and support, I presented both papers to engage with the external expert community in Asset Management. Promoting the Unit's design approach in 2014 helped me persuade several senior industry practitioners and technical experts to provide high quality materials and come to lecture on the Unit. The input from these practitioners was hugely appreciated by students. I was also asked back to the next conference to present on the Unit's delivery. This engagement with senior practitioners was very valuable for the Unit's internal and external professional credibility.

3 Discussion

I identified five key challenges during and after the design and inaugural running of the Unit in 2015: *engagement; scope; technology; feedback and testing*. These were published and presented at the 2015 Asset Management Conference to pass on our experience to the wider asset management community (Figure 2). I have tracked performance on these challenges over 3 delivery cycles as the Asset Management profession has had a lot of technical and process changes including new or updated technical standards and key reference documents published (see Annex A). This created a highly dynamic environment for me to implement the new Unit and I wanted to ensure that all parties could cope with this. In more detail, the five challenges I identified were:

1. *Engagement*. I needed to make asset management a stimulating subject for students with commensurate levels of engagement. This included co-planning what we could effectively cover in 5 months, given the wide range of topics available.

⁴ Montserrat Díaz-Méndez, Evert Gummesson, (2012) "Value co-creation and university teaching quality: Consequences for the European Higher Education Area (EHEA)", Journal of Service Management, Vol. 23, Issue: 4, pp.571-592,

⁵ Crossley, A & Male, S, (2014) Designing an Undergraduate Module in Asset Management.

Proceedings of the Asset Management Conference 2014. Institution of Engineering and Technology

⁶ Crossley, A & Male, S, (2015) Delivering a new undergraduate module in Asset Management. in: Proceedings of the Asset Management Conference 2015. Institution of Engineering and Technology

2. *Scope.* I needed to ensure that our teaching was consistent with the latest asset management Body of Knowledge (BOK). This included planning lectures from leading industry practitioners to explain about their world of asset management activities. In the first two delivery cycles, we agreed to provide some templates for the students to be able to compare two major infrastructure asset management plans from the UK public sector. I felt this would reduce student risk and save time.
3. *Technology.* As agreed with the co-creators, I designed the Unit's new material using appropriate and highly accessible technologies. This was challenging for me as some of the technologies were relatively new at Bristol and I needed to be trained in their use and then deliver onward training to my students and colleagues too.
4. *Feedback.* Based on cohort surveys, this is known to be a challenging area at Bristol and in Engineering. I therefore needed to effectively test the knowledge acquired and gather comprehensive feedback on the combination of lectures, research, reading, reporting, modelling, and examination. Whilst I have achieved considerable progress using pedagogically robust approaches, such as those promoted by Cowan and Harding, in 2017 there remains a small minority of students wanting more personally tailored support and advice. After the third cycle, I wrote to the students with a summary of why topics were taught and how we have updated delivery of the Unit based on three cohorts' accumulated suggestions.
5. *Testing.* I agreed with the co-creators to design a trial test and then use an advanced computer based tool for the final examination that would ensure a fair method of individual testing and subject coverage. This required balancing the challenges of a new form of exam against the assessment needs of a Level 7 qualification.

Figure 2 summarises these key challenges. The remainder of this case study looks at these five challenging areas using the Gibbs model, highlighting what I implemented and what to consider for future Unit design and then has an overview of the Unit's achievements to date.

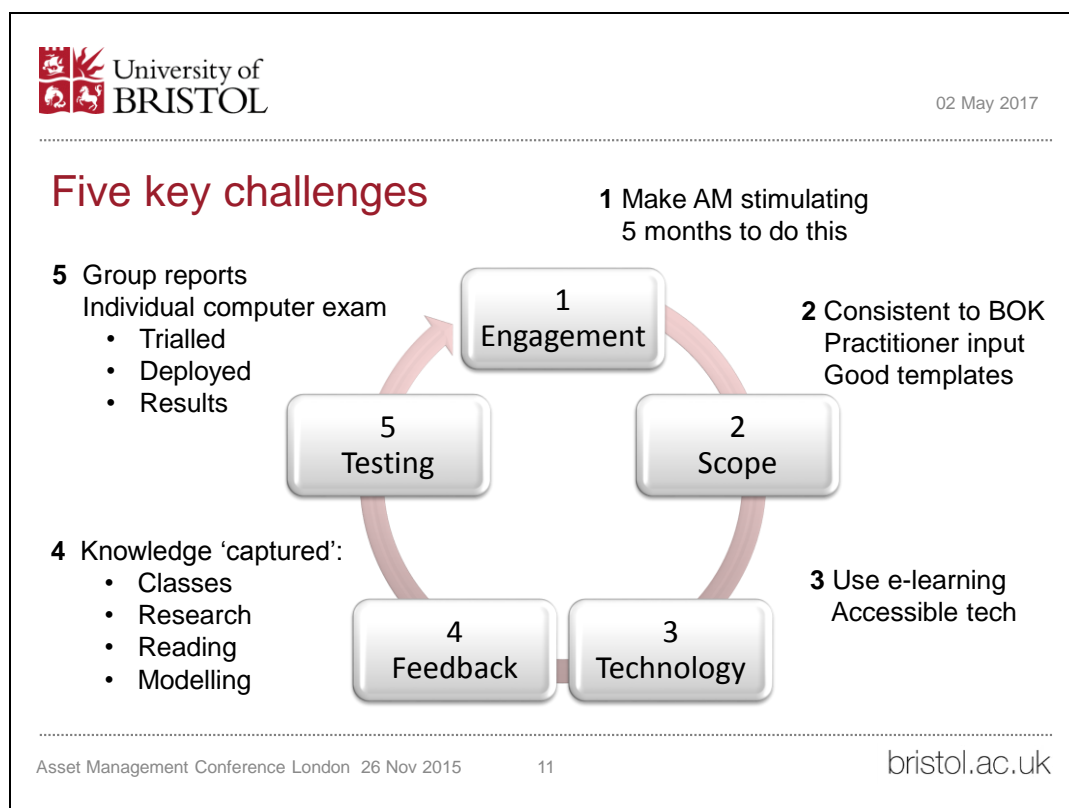


Figure 2. The Asset Management Unit's Five Key Challenges

3.1 Engagement

Design. My first challenge was engagement, working with a sample of very good students as co-creators to meet all their needs. My overall feeling about this was to be 'cautious' as I needed to recognise our planning and delivery time constraints as well as managing their overall expectations. I have established an external research and implementation track record in advanced collaboration processes and systems, especially in Engineering, training and project development starting in 1998. Based on this practical experience, and my academic research into co-creation within Higher Education, I took the initiative to invite a team of three final year Civil Engineering Undergraduates and a final year student in Engineering Design to become involved in the co-creation of the Unit. All of them were volunteers interested in the asset management subject area, some as potential career tracks. My approach was grounded in the observations of Lepper⁷ that *"A student who is intrinsically motivated undertakes an activity for its own sake, for the enjoyment it provides, the learning it permits, or the feelings of accomplishment it evokes."* At the time, I felt that this was a potential risk, as there were no examples of Unit co-creation with the Civil Engineering programme.

Assess Delivery. On evaluation of the engagement stage I identified the following good experiences and areas for improvement:

- Good – Listening to the needs and wants of my student representatives.
- Areas for Improvement – Trying to meet all their needs within a 10 credit Unit's 13-week lecturing time required more time than I originally had available. In future, I recommend that co-created Units have appropriate planning time/resources.

Reflect on Possible Improvements. To plan for success, I felt that I needed motivated students co-developing the Unit. My own role was to act as a small group facilitator for these preliminary planning sessions, guiding the students on technical aspects of asset management, where appropriate, as recommended by McCrorie⁸. This also helped me build a strong 'partnership' with these influential students, as advocated by one of my external business partners Stephen Dent⁹. My goal was for these four students to: help me create a 'buzz' around the Unit; to be a useful source of feedback as it was being delivered; and, to regularly check that I was meeting their expectations. This demonstrated three of Dent's six attributes working with them, our: 'comfort with interdependence'; 'ability to trust'; and, 'win/win orientation'. My subsequent analysis is that I would strongly recommend using this co-creation approach.

Modify aspects of design. Having a sample of students engaged in the design does not automatically mean that all the students are engaged. A small minority wanted more personalised tuition and so I offered drop in sessions to help them. I needed to plan for more of these drop-in sessions in my own timetable, outside of formal lectures to cater for the additional needs of some students and help with their engagement. These changes I implemented have helped me market the Unit and about 50% of each cohort have signed up to do it. On overall engagement, I concluded that Bristol's Engineering students are good at planning their work and explaining their needs. The co-created design and student enthusiasm was refreshing - in effect, the first cohort 'owned' AM4. I therefore need to carry on with new cohort engagement and ownership, potentially by giving each new cohort alternative lecture options and having more lecture interaction on the case studies.

⁷ Lepper, M.R. (1988) Motivational Considerations in the Study of Instruction, Cognition and Instruction Vol 4, Issue 4

⁸ McCrorie, Peter (2006) Teaching and leading small groups. Edinburgh, UK: Association for the Study of Medical Education. 32p. (Understanding Medical Education) ISBN 0904473376

⁹ Dent S.M. and Krefft J.H. (2004) Powerhouse Partners: A Blueprint for Building Organizational Culture for Breakaway Results. Davis-Black ISBN 0891061959 p27

Assess Latest delivery. There is still a 5-month teaching and testing window, including a 'mock' exam, revision and the finals in late May. The last month in the semester is dedicated to group work submission and exams. The annual programme for 2015 is given in Annex D it has been slightly modified for 2017 based on 2015 and 2016 cohort feedback. This 'cyclic' systems approach retains a stimulating mix of content. The lectures by expert practitioners and researchers help bring some complex topics to life. Students consistently ask relevant and challenging questions to these experts, demonstrating high levels of engagement.

3.2 Scope

Design. My second challenge was how to align an L7 Unit to the IAM main 'competences'. This was taxing for me because there was a limit on my teaching time and the student's allotted learning time. Hence, I needed to prioritise content. I recalled another of Cowan and Harding's point that *"Nothing that takes place in the course is relevant or purposeful unless it serves to further the Aims"*. Therefore, I used the Unit's Intended Learning Outcomes (ILOs) to determine topics, learning and assessment. AM4's aims are to:

1. Understand and apply the key principles of Asset Management.
2. Identify engineering activities required to promote and contribute to asset development.
3. Understand and analyse basic asset and related investment performance indicators.
4. Understand and apply the principles of asset health monitoring and condition-based maintenance.
5. Understand the framework of relevant legal requirements governing asset condition.
6. Apply integrated management systems for health, safety, environment, and quality.
7. Treat asset knowledge and innovation as business assets.
8. Appreciate the need for a high level of professional conduct in Asset Management.

The ILOs were carefully planned with the Programme Director to put robust 'Aims' at the centre of my planning. Having these Aims helped me focus on content. What has changed over 30 years since Cowan and Harding's paper is the level of involvement of students from passive recipients of 'design' to co-creators of a Unit's content. I use Figure 3 at the start of each lecture to help explain the linkages between the Unit's Intended Learning Outcomes with the core competencies required within the IAM's qualifications.

Assess Delivery. After the first cycle, I looked at some student evaluation that the reading and expected workload was quite high when compared to more traditional quantitative and design base Units. The Unit coverage and programme are covered in Annex B.

Reflect on Possible Improvements. On reviewing the student evaluation of the Unit's scope, I identified the following good points and areas for improvement:

- Good – Meeting many of the IAM's goals meant the Unit was professionally focused.
- Areas for Improvement – Working out what might have to be changed or possibly even left out, based on evaluation. I found that there is a tricky balance to make on student workload between the perception of a minority of the students and the time commitments and ILO requirements of a 10 credit Unit at Bristol.

On reflection, I believe that the combination of the practice of 'student centred learning' and viewing students as 'partners with Bristol their own education' still validates my decision to co-create the Unit with our students. This is an appropriate approach for the millennial generation because proactive involvement and strong expression of their viewpoints is a given, from their perspective. The University's recent design of the Bristol Future's approach to self-awareness and personal skills development complements this approach.

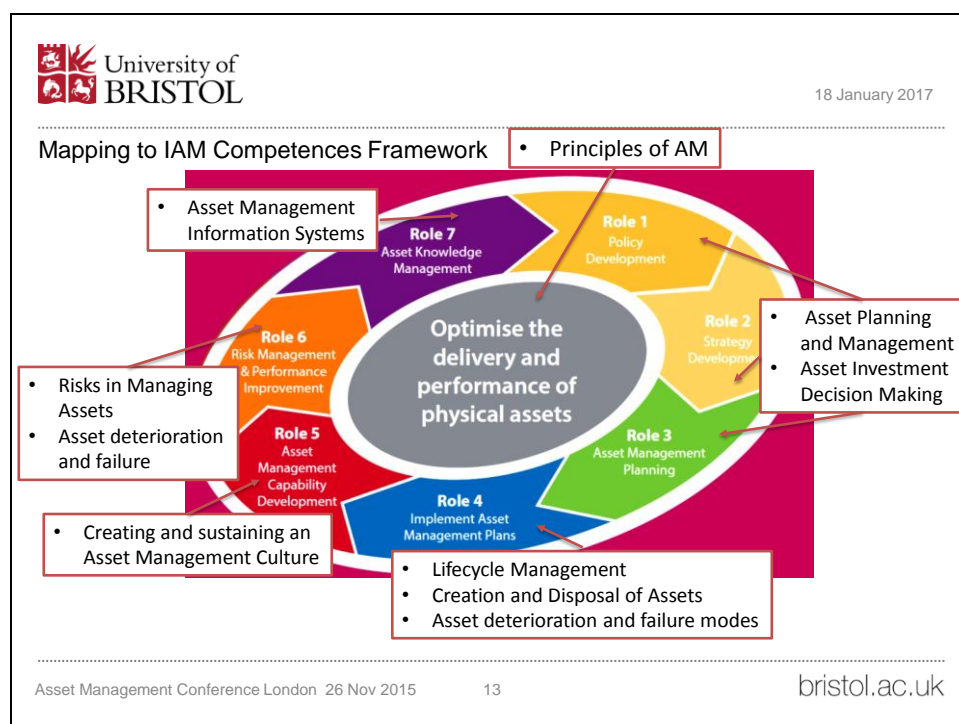


Figure 3. The AM4 Summary Curriculum based on the IAM Competence Framework

Modify aspects of design. Based on the first cohort's feedback I reduced the volume of pre-reading expected for Cohort 2. Cohort 2 then asked us to re-design the assignment from one comparing two major transport organisation's Asset Management Plans, using a standard framework, to assigning Cohort 3 with the preparation of a new Strategic Asset Management Plan (SAMP), from first principles – to test their acquired knowledge.

Assess Latest Delivery. The intent of changing the assignment, based on Cohort 2's feedback, was sound. However, this latest change resulted in polarised opinion and evaluation within Cohort 3 and polarised assignment marks (51 – 85%). The eight groups in Cohort 3 seemed to either 'get it', that they needed to do research and design their reports, or stated that we needed to provide more directed guidance on the structure and content of the SAMP. The latter viewpoint was critically reviewed by Dr Male and I. In consultation with the Programme Director and the Examinations Officer it was decided that the assignment and the assessment were entirely appropriate for a Masters (L7) Unit. I then prepared a detailed Unit review post 2017 completion, covering the key issues the student feedback had raised. This was fed back to the students along with a thorough explanation of our reasoning. This report appears to have been accepted by the students, especially when most of the students balanced our detailed analysis with their good marks on the Unit.

3.3 Technology

Design. My third challenge was adapting our learning technology and third-party technology, such as the IAM's self-assessment modelling (SAM) systems, to optimise delivery. Here I felt initially exposed because I needed to quickly set up a coherent system for e-learning integration. In 2004 Lea¹⁰ stated that "*Academics and course designers need to know who their students are and what experiences they will bring to their studies...tutors need to find out as much as they can about students' prior experience of writing, of reading, and also, in this instance, of using ICT.*" I agree with her. However, by 2017 the level of mutual

¹⁰ Lea M. R. (2004) Academic literacies: a pedagogy for course design Studies in Higher Education 29:6, pp 739-756

understanding and student/tutor interdependence with learning technologies has moved on. A student in 2017 demands a seamless multi-media based learning experience that is accessible using a range of portable devices as well as traditional PCs. Annex C describes my approach to TEL for the Unit.

Assess Delivery. The whole subject area of students' different learning goals and styles, as highlighted in 2009 by Ulriksen¹¹, combined with modern Technology Enhanced Learning (TEL) and the ready access to vast amounts of high quality information on line, have all led to innovative ways of acquiring knowledge, inside and outside the formal classrooms of the 2000s. It is interesting to reflect that Google Scholar was released in beta form in 2004. By 2014 researchers¹² had estimated that it contained 160 million documents. All of this is available outside of the formal classroom setting. To maximise the experience of going to University, I believe that it is still important to encourage students to want to attend lectures to interact with others. Therefore, our incentive is having external practitioners giving students the benefit of real world experience and a chance to ask relevant questions but with the Unit's knowledge supported by a seamless e-learning system using appropriate technology.

Reflect on Possible Improvements. On evaluation of the Technology challenge I identified the following good experiences and areas for improvement:

- Good – My work on Civil Engineering Systems 3, especially the use of a real-time support forum and enhanced Blackboard content with videos and relevant hyperlinks to key external content, gave me a good start (see my other case study).
- Areas for Improvement – The high pace needed for e-learning system integration and content population created pressures both in the formative support and in the examination preparation. I recommend a TEL plan be prepared for any new Unit.

Modify aspects of Design. My reviews and analyses concluded that it is important to plan TEL support systems, aligned to predicted training and development needs, at the outset. For this challenge, I deduced that it is important to plan and assess the added value that high-quality technology can bring to teaching and learning. For larger cohorts, it saves time and increased both precision for formative and summative assessment and feedback. For smaller groups, it may not prove so beneficial because of the return on the considerable time investment. I am also looking at writing a complementary take/update on Ulriksen's paper about 'The Implied Lecturer', given the availability of TEL and remote working.

Assess Latest Delivery. The combination of pre-publication of lectures, use of media in lectures and software in workshops, using Media-Capture and the Support Forum technology has embedded TEL into the Unit. There was one student in 2017 who feedback that the material was challenging for him/her to 'manage' as it was comprehensive and not in 'lecture week' folders. The report referenced in 3.2 above detailed why our Blackboard content was reverse chronological and was provided in such a way that the individual student could access/download and restructure content according to his/her own needs. Whilst I do not propose to change this approach, the School Education Director is looking to create a standard Blackboard template for 2017/18 onwards with limited migration rights from earlier years. He is aware that the Support Forum is critical to the system and has been requested to ensure it migrates over.

¹¹ Ulriksen, L. (2009) The implied student. *Studies in Higher Education* 34:5, 517-532

¹² Orduña-Malea, E., Ayllón, J.M., Martín-Martín, A., Delgado López-Cózar, E. (2014) About the size of Google Scholar: playing the numbers. *Granada: EC3 Working Papers*, 18: 23 July 2014

3.4 Feedback

Design. My fourth challenge was the crucial one of knowledge capture and feedback. Developing effective learning, assessment and feedback for a new Unit is not a straightforward process. In this case the co-creation helped and I felt very enthusiastic on getting the initial engagement of students and the input of AM and educational experts about the approach to designing learning and feedback.

Assess Delivery. On analysis, there was overall benefit in having the students help plan the Unit and then having regular reviews on whether the plan is working to keep everyone on side and on track. I also concluded that, for Units that link to real world delivery and practice, having top advisers is very useful. The corollary is that it is risky for Bristol to over 'internalise' Units related to professional practices. In my original discussions with our co-creation students, they liked the mix of an exam and some form of joint report, having had a lot of positive experiences in team working and joint report writing since the start of their third year. They also recognised that, as a final year subject, some form of individual assessment using an end of year exam was sensible. From the learner's perspective, the additional 'goal' to pass the exam meant that all group members needed to study all the required learning material. I find that this balanced combination of coursework and exam is effective from a quality perspective, as well as being preferred by students per Starr¹³ in 1970 and validated in 1996 by Kniveton¹⁴.

Reflect on Possible Improvements. On evaluation of the Feedback stage I identified the following good points and areas for improvement:

- Good – Three-way teamwork students/staff/externals was a comprehensive approach.
- Areas for Improvement – The time needed to map out all the lectures and reading into a limited timeline created some tensions between what must be covered, what was nice to cover and what was critical to learn. Whilst the scope issues and reduced reading requests from the 2015 and 16 cohorts had been effectively dealt with some 2017 student evaluation thought there was still a lot of material to cover. This was interesting as it was not raised by the 2016 cohort, implying that the 2017 cohort were potentially spending less than the planned time on the Unit, despite the 100-hour target being raised at the start, reinforcing the observations I made in 3.2 above. Annex D contains a summary of Unit reviews.

Modify aspects of design. Establishing how to carry out feedback and what is to be assessed is very challenging. Over 40 years after Parlett and King's¹⁵ research on student's strategic approach to learning and assessment, it is still the case that students want 'up front' information on how a Unit is to be assessed. Gibbs and Simpson¹⁶ highlighted this over a decade ago. *"Students work out for themselves what counts – or at least, what they think counts and orientate their effort accordingly. They are strategic in their use of time and 'selectively negligent' in avoiding content they believe is not likely to be assessed."*

In 2017, I wondered whether the burden of: HE fees; student debt; parental and future employer related pressures for high grades; and, the stringent requirements of a top MEng

¹³ Starr, J.W. (1970) Student opinion on methods of assessment, Educational Review Vol 22, pp 243-253

¹⁴ Kniveton, B.H. (1996) Student perceptions of assessment methods, Assessment & Evaluation in Higher Education, Vol 21, No 3, pp229-238

¹⁵ Parlett, M.R. and King, (1971) J.G. Concentrated Study (Monograph 14), Society for Research into Higher Education. London.

¹⁶ Gibbs, G and Simpson, C (2004) Conditions Under Which Assessment Supports Students' Learning, Learning and Teaching in Higher Education, Issue 1, 2004-5

degree, all combine to shift focus away from learning towards assessment. After all, assessment is only one means of validating learning. In the 2017 Unit review report I highlighted that some students' over-focus on assessment rather than learning can potentially diminish the overall experience of option selection and knowledge exploration.

Assess Latest Delivery. Reflecting on three years of running the Unit, I have noticed that some students over focus on how they are assessed, and this can even negatively influence their decision to take the elective. In 2018, I will re-emphasise the time planning aspects and discuss and provide a Unit planning template for the students to build on. I have done this for a third year Unit since 2014 and had therefore assumed, perhaps wrongly, that the ability to self-prepare their own template had carried forward from what I had taught the same students in their third year.

3.5 Testing

Design. Initially, I felt that adopting the new online exam software called QuestionMark Perception (QMP) was a risk. The related risks included my personal training and prototyping work on developing a final examination. The QMP technology was also in its initial stages of adoption within Engineering. However, I was keen to use this because I knew that adopting online exam software would prove to be beneficial in marking efficiency and accuracy as the Unit expanded over time. My experience with the IAM's professional exams reinforced this belief. Annex E explains the testing methodology for the Unit.

Assess Delivery. My audit and analysis has revealed that there is a steep learning curve to master QMP for my delivery and support team but less so for the students. To help the students we used a mock exam/test to ensure all the log on procedures are correct, to give them experience of the system, and to trial the range of types of questions they may encounter in the final exam. The Technology Enhanced Learning (TEL) team at Bristol were very supportive and able to help me set up the first and subsequent exams effectively. However, getting each exam set up correctly takes time as the University, the Exams Officer and the External Examiner all require paper copies as well i.e. I need to prepare two versions of the exam. This is driven too much by pre-existing, paper based, protocols and a 'fear' of overall system failure in the allotted exam schedule i.e. QMP doesn't work or there is a power cut. Unfortunately, a paper back up would need a rescheduled exam room in the event of a power cut, as the Engineering computer exam rooms have no natural light!

Reflect on Possible Improvements. On evaluating the Testing stages, I identified the following good points and areas for improvement:

- Good – Mastering QMP gives fast/accurate results within minutes once the exam is completed.
- Areas for Improvement – Far more time is taken populating QMP than a written exam. More detail and precision in model answers is also needed for QMP exams than a traditional paper based exam. This has a heavy workload implication during January and February with detailed internal and external checking leading to an exam sign off 'log-jam'. I therefore need to start the exam design in November.

Modify Aspects of Design. Taken with the comments made above, on a paper based examination culture in Bristol, I am discussing whether a 'print out' from the QMP system will suffice for the Exams Officer. Whilst he seems amenable, there are going to be some differences between the QMP print out and Bristol's 'traditional' paper based templates.

Interestingly, one of the best students questioned the selection of available multiple choices answers on a financial question in the 2017 exam, to the extent that she asked the invigilator to contact me in the USA. Despite our assurances that the model answer had been

separately checked by three lecturers, the Exams Officer and the External Examiner she remained concerned enough to write to us after the exam. One unintended consequence of on line exams is the increased student stress if their view of the 'correct' answer is not available. Fortunately, she did get the right answer on the day but was clearly concerned about her perception of our quality assurance.

Assess Latest Delivery. One conclusion for the Unit's management team was that spending more time in training to create good QMP questions is essential. As I only had half a day back in 2013, I needed to 'learn by doing' over the first few cycles which was not ideal but very pragmatic. The above student's examination experience validated the need for me to hold practice exams and more QMP based tests to build student and staff confidence. For completeness, Annex E explains the design of the final exam and the use of the QuestionMark Perception software together with the views of the External Examiner.

4 Conclusions

For this case study, I carried out a detailed analysis of the Unit using Gibbs' Reflective Cycle covering: design; assessment of delivery; reflecting on possible improvements; modification based on feedback and results; and then assessing the latest delivery for three cycles. This has helped me update the content and the students achieving improved results culminating in excellent coursework and exam results for 2017.

I described the key challenges and decisions needed for the Unit and the main action plans set out in Figure 2 and discussed in section 3. Following on from the Crossley and Male 2015 Paper, the key recommendations from the case study are:

1. **Overall Delivery Cycle.** Get Programme Director guidance and a realistic timescale for planning for all new Units.
2. **Engagement.** Use co-creation with students but start the consultation with them early as engineering students are very busy. In future, I would get at least one more international student involved, as AM is international.
3. **Scope.** I recommend aligning similar 'practitioner' based Units with professional accreditation where possible. It worked well in principle and helped me in my teaching and external IAM work. I have concluded that if you align a new Unit with professional accreditation requirements, students get greater learning value and improved employability. It may be perceived to be a 'hard' Unit for some of the cohort but to date several of the Unit's students have progressed into careers in Asset Management, which was part of the Unit's design considerations.
4. **Technology.** I have learned a lot from setting up AM4. I have helped colleagues set up their TEL systems effectively. This case study will help me develop that initiative.
5. **Feedback.** Having early discussions with industry experts by presenting a paper on Unit design proved very helpful to get them on board and the students fed back that they appreciated the industrialists' inputs. I have also followed up on student Unit evaluation, especially in the reduction of case study pre-reading (one article a week, not two) and the changes to the Cohort 3 assignment.
6. **Testing.** More Unit Directors should be taught how to use QMP to get the best value from this technology for Bristol. It is both efficient, in terms of marking larger volumes of papers, and effective, in making marking accurate and consistent within the cohort.

After three years of running the Unit, my overall reflection is that if you try hard enough, you can synthesise appropriate content within a time constrained teaching environment. However, there is room for expanding L7 teaching and learning in Asset Management if it were a 20 credit Unit or two 10 credit Units within the Infrastructure Systems 'strand' in Civil Engineering: Principles of Asset Management and Modern Asset Management Practices.

This has been raised with the Department as part of the strand review in 2017. It also aligns to the two levels of the IAM's examinations – principles and practices.

I hope that this new case study has added to the overall body of knowledge on Unit Design and the introduction and alignment of Undergraduate Units to industry competence requirements and frameworks. Finally, co-creation with students is a very positive way forward.

Annex A – Context and the Changing Technical Environment

People. Infrastructure Asset Management is a relatively new subject area and the Unit's Director (myself) and Co-designer (Stephen Male) have professional connections with the Institute of Asset Management (IAM). Both of us have served on the IAM's Examinations Committee. Dr Male was also on the IAM Examinations Board between 2013 and 2016 as the Chief Examiner. I have taken over the role of the IAM's Chief Examiner for three years starting in December 2016. Dr Male was also the Professor of Asset Management, and my MSc dissertation supervisor, when he was the Programme Director of the taught MSc in Asset Management at the University of Leeds between 2001 at 2008. We have worked together in research, business, and academia since 2003 and so I have been able to learn a great deal from this internationally regarded expert in the subject.

Environment. In our 2015 Asset Management conference paper, we highlighted the major changes impacting asset management during the design and initial delivery stages of the new Asset Management Unit. These are described in the following paragraph.

“In 2014 the asset management body of knowledge underwent extensive changes and improvements with: the introduction of ISO 55000¹⁷; the updating of the Institute of Asset Management's (IAM) Anatomy¹⁸; the re-alignment of the International Infrastructure Management Manual to ISO 55000¹⁹; the full introduction of the IAM's Self-Assessment Methodology (SAM)²⁰; the revisions to the GFMAM's Asset Management Landscape²¹, and their Assessor Specification²²; and the roll out of the Professional Certificate and Diploma examinations in Asset Management by the IAM. The Institute of Public Works Engineering Australasia launched its Professional Certificate in Asset Management Planning in April 2014²³, complementing the New Zealand Asset Management Support Group's National Diploma in Infrastructure Asset Management²⁴.”

¹⁷ BS ISO 55000/1/2:2014 Asset Management, BSi (2014)

¹⁸ Supplement to the IIMM 2011 - Quick Guide: Meeting ISO 55001 Requirements for Asset Management v1.0, IPWEA and NAMS (2014)

¹⁹ Asset Management – An Anatomy: Version 2, Institute of Asset Management (2014)

²⁰ Institute of Asset Management, Self-Assessment Methodology, Guidance, Version 1, June 2014, and Asset Management Maturity Scale & Guidance, Version 1, June 2015

²¹ Global Forum on Maintenance & Asset Management (GFMAM), The Asset Management Landscape. 2nd Edition, 2014

²² GFMAM, Competency Specification for an ISO 55001 Asset Management Systems Auditor / Assessor. First Edition, Version 2, 2014

²³ Institute of Public Works Engineering Australasia (IPWEA), Professional Certificate in Asset Management Planning, <http://info.ipwea.org/professional-certificate-asset-management-planning>, accessed 13/09/2015

²⁴ New Zealand Asset Management Support (NAMS), National Diploma in Infrastructure Asset Management, <http://nams.org.nz/pages/36/world-class-national-diploma---infrastructure-asset-management.htm>, accessed 13/09/2015

Annex B – Unit Coverage and the Original Design

| IAM Competences Role | Unit Subject | Delivery | Group Project |
|---|---|---|---|
| Key Purpose of Asset Management | Principles of AM | 2 lectures by Industry Experts, industry case studies | Team based project involving critical analysis of 2 asset management plans and potentially the use of IAM's SAM tool or other diagnostic and assessment techniques. |
| Policy Development, Strategy development, Asset Management Planning | Asset Planning and Management; Asset Investment Decision Making | 4 lectures by Industry Experts and Academics, industry case studies | |
| Implementing Asset Management Plans | Life cycle management; Creation and Disposal of Assets; Asset deterioration and failure modes | 4 lectures by Industry Experts, industry case studies | |
| Asset Management Capability Development | Creating and sustaining and asset management culture | 2 lectures by Industry Experts and academics, industry case studies | |
| Risk management and performance Improvement | Risks in Managing Assets; Asset deterioration and failure modes | 2 lectures by Industry Experts and academics, industry case studies | |
| Asset Knowledge Management | Asset Management Information Systems | 1 lecture by Academics, computer lab, industry case studies | |

Table C1. Mapping of the AM Unit design against the IAM's Competencies Framework

| Week | Subject | Lecturer, Organisation |
|-------------|---|--|
| 1 | A practitioner's introduction to asset management Unit design and programme | C Lloyd, CAS and IAM A Crossley, Bristol |
| 2 | <i>Heathrow Airport 24/7</i> Creating and sustaining an asset management culture | P Burcombe, Heathrow Airport S Male, Bristol |
| 3 | <i>Water Works</i> - the industry's approach to asset management | M Greetham, Bristol |
| 4 | <i>Keeping The Lights On</i> - National Grid's approach to asset management <i>Lifecycle Management</i> -The challenges of creation and disposal of major Assets. | D Dunkley, National Grid S Male, Bristol |
| 5 | Asset Management Information Systems | A Crossley, Bristol |
| 6 | Using the SAM tool (Computer lab session 1) | A Crossley, Bristol |
| 7 | <i>Bridging the Gap</i> – Asset deterioration and failure modes <i>Bridge Management</i> – Practical challenges | M Kashani, Bristol S Luke, Jacobs |
| 8 | <i>Water Water Everywhere</i> – flooding, resilience and asset management Financial and business impact of good and poor asset planning and management (Railtrack, Network Rail and London Underground) | S Male, Bristol A Crossley, Bristol |
| 9 | Open house Q&A on assignment and approach to 'mock exams' | A Crossley, Bristol |
| 10 | Asset management 'mock exam' (Computer lab session 2) | A Crossley, Bristol |
| 11 | <i>Systems, Resilient Cities & The Built Environment</i> Risks in managing assets | S Passmore, TEST S Male, Bristol |
| 12 | Asset investment decision making | A Crossley, Bristol |
| 13 | Exam planning and Unit summary + Q&A | A Crossley, Bristol |

Table C2 Lecture Content for 2015 Delivery Cycle

Annex C - Technology Enhanced Learning

The following systems for Technology Enhanced Learning (TEL) were used in the effective delivery on the Asset Management 4 Unit - abstracted from Crossley and Male (2015):

1. *“Blackboard. This e-portal is used for planning, communication and dissemination of the Unit’s materials. It allows all users to tailor their degree of access including instant notifications when new material is added to the learning space such as: announcements, articles, lecture slides and notes, relevant videos and video links, interim assessments together with a high quality interactive support forum for the raising and responding to questions. The Blackboard Support Forum is especially useful as it is a searchable database by topic, key word and response ranking. The Forum allows real time dialogue between all parties. Students are also encouraged to support each other with relevant references and advice in this moderated environment. This is set up for mobile access using the iOS and Android platforms.*
2. *BSOL. All students have access to British Standards Online to ensure they have the latest asset management and related standards. This is a searchable resource and standards are made available in PDF format for marking up and searching. As with Blackboard the BSOL is available via mobile technology using virtual desktop from the ‘My Bristol’ portal.*
3. *ICE Virtual Library. The two set texts by Lloyd were made available to the participants as on-line resources either to read or download by relevant chapter. As the case studies within the reading list and used for class discussions were all potential topics for the final examination, the ability to download and annotate the material was a real advantage to the students. Typical access was via tablets and laptops.*
4. *IAM website. Some material referenced in the Unit’s lectures was available via the site www.theIAM.org for the students using guest or registered affiliate access. The excellent videos hosted on the site were very useful and the Anatomy v2 and v3 were both well regarded as concise supplements to the Unit’s taught material. Students were all encouraged to consider joining the IAM either as Affiliates, Student Members or NXTGen members on graduation. The IAM home page was a Unit link.*
5. *Self-Assessment Methodology (SAM). Students were taught about the IAM’s SAM tool in class and computer labs. The SAM tool was then used to carry out in-depth comparative analysis of two major asset owners’ asset management plans. The asset owners were drawn from different sectors. Given the students’ speed of learning and the capability at using the tool, they gave some valuable insight on the usability and complexity of SAM.*
6. *QuestionMark Perception (QMP). QMP was used to practice for a mock examination with instant grading and explanatory responses. The mock was set up in exam conditions. It was then used in the final examination.”*

Annex D – Summary of Unit Review

“On reviewing the Unit, the students said they appreciated the input and commitment of time from the visiting speakers. They recommended this be reinforced with a site visit to see a major asset related activity for the Unit’s delivery in 2016.

The students fed back concerns over the volume of material they were expected to read and prepare for the next lecture. This was expected to take approximately an hour a week before the next lecture. The students explained that the preparatory work was taking closer to two hours. This was too much, given the large amount of work in the final year of the MEng programme.

The students recommended that pre-reading be limited to one article, chapter or video so that they could be fully prepared to respond in the lecture setting. This was valuable feedback to the Unit’s designers and will be implemented in future years.”

As a ‘benchmark’ I worked with Steven Male to compare the Unit’s first cycle with that recommended by Zuashkiani et al.²⁵ Our 2015 paper covered this in detail especially the balance of Asset Management living between the ‘hard’ science and numeric subjects, such as Structural Engineering, and softer managerial subjects such as Professional Studies (a second year Unit in Engineering) and Civil Engineering Systems (third/final year). To quote the conclusions of the Crossley and Male 2015 Paper:

“The new Asset Management Unit required innovative approaches to delivery including:

- 1. Designing and delivering a curriculum which provided a sense of the breadth of asset management and also permitting candidates to delve into its deeper aspects through team-based comparative analytical work on two Asset Management Plans.*
- 2. Working with four volunteers from the student body to plan engaging content and topic coverage, with the students acting as end users/customers using ISO 9001 principles.*
- 3. Getting the buy-in and support of busy asset management practitioners and thought leaders.*
- 4. Designing, populating and accessing high quality digital learning systems using mobile technologies.*
- 5. Students interviewing asset management leaders about their policies and practices.*
- 6. Gaining the approval of Internal and External Examiners for the use of computer examinations at the ‘final’ degree level examinations.”*

²⁵ Zuashkiani A., Schoenmaker R., Parlikad A., & Jafari M., (2014) A critical examination of asset management curriculum in Europe, North America and Australia, Proceedings of the IET IAM International Asset Management Conference, November 2014.

Annex E - Testing methodology for the Examination

This was abstracted from the Crossley and Male 2015 paper:

“After considerable assessment and quality assurance testing, QuestionMark Perception was chosen as the final examination tool for the module.

Designing and testing the QMP question bank was a highly detailed and thorough process. The department’s External Examiner was very interested in its use in a final examination. Adopting this route entailed far more preparation time in setting the examination in January 2015, with extensive quality assurance processes adopted both internally and externally. The process starts with a question set built in MS Word. Each of the authors then checked all the questions. The exam paper was then reviewed internally for accuracy and intelligibility prior to sending to the External Examiner for final approval.

Initial External Examiner feedback highlighted the approach was innovative for a final MEng examination and that the marking system needed careful design to ensure guesswork on responses was not rewarded. The team considered whether to use negative marking for incorrect responses. However, when this had been used for testing in second and third year professional studies management Units some students had expressed concern over what they had termed potential ‘shades of grey’. The Unit design team therefore decided to use variable scoring for more complex comprehension and scenario type questions with full marks for a ‘perfect’ answer and around 50% marks for the next closest answer - a near miss. No marks were awarded for the three remaining responses. This approach was verified as effective in the mock exam.

Exams are managed in a highly-invigilated environment as required by the University’s codes and regulations. This meant that a special ‘closed’ computer laboratory was needed for the final exam with no external access to web sites, memory sticks or mobile technology.

All students had to have individual passwords and the technology automatically times them out at 2 hours or 2.5 hours for those students registered as requiring additional time. The technology also tracks progress during the exam by ‘greying’ out completed responses. This enables students to return to incomplete questions later in the exam, for efficiency.

The balance of the range and complexity of questions and the time planning proved effective. Of the 46 students sitting the first run of the exam, less than 10 completed the exam and left before the final 15-minute deadline. The students requiring extra time made full use of it.

The results were processed by the QuestionMark system then exported into a database for checking. The scores for each question and the time taken for the paper by each student was available within 30 minutes of completing the exam. All the students passed the exam with marks ranging from low 50s to high 80s expressed as percentages. This saved the examiners about 60 hours of marking and cut out the potential for any errors in scoring papers. It also gave consistency in marking.”